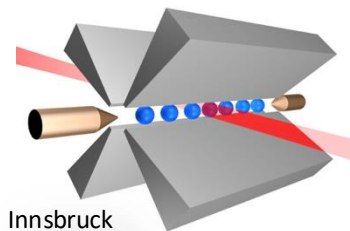


Experimental Quantum Computing and Quantum Error Correction

Lecture 3: Optical and spin qubits

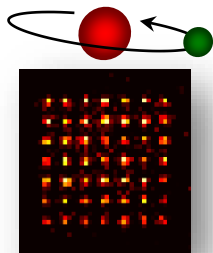
The qubit zoo

Trapped ions

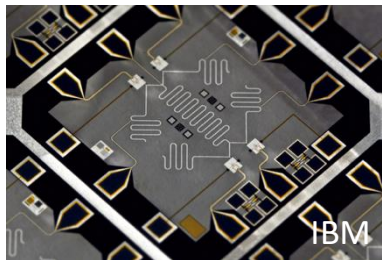


Lecture 2

Atoms

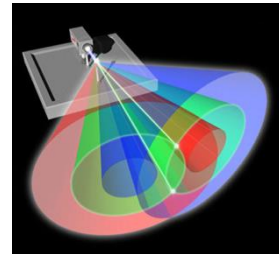


Superconducting circuits

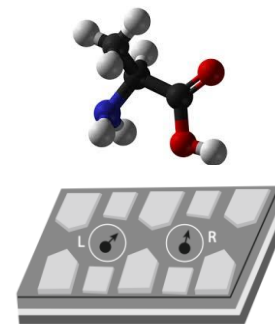


Lecture 4

Photons



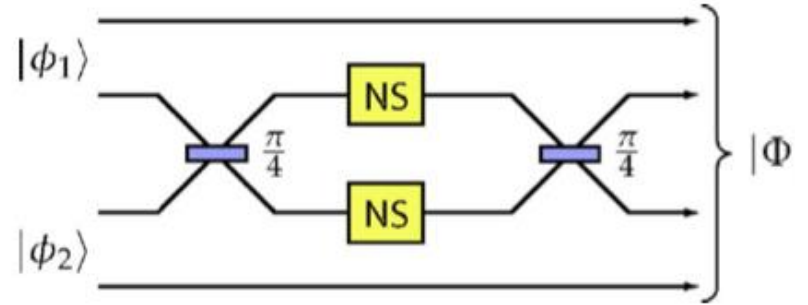
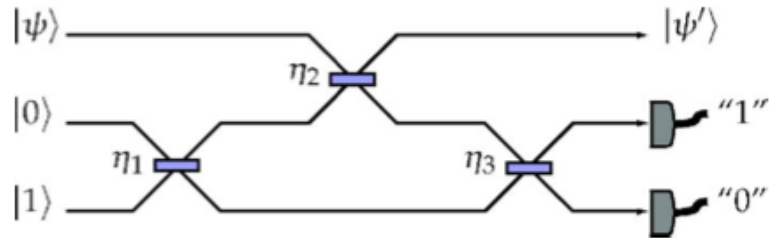
NMR & e⁻ spin



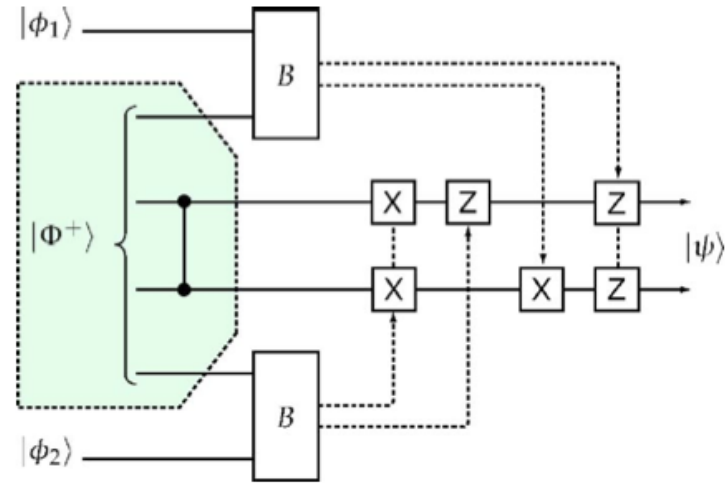
Lecture 3



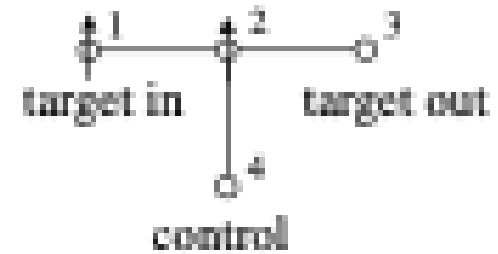
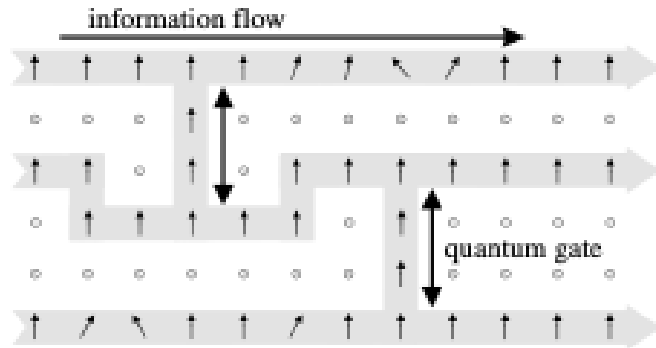
Probabilistic photonic gates



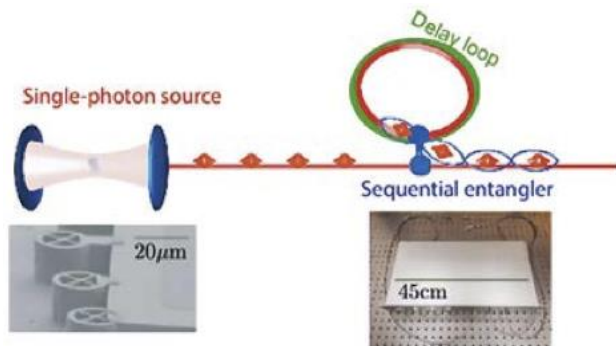
Two-qubit gate teleportation



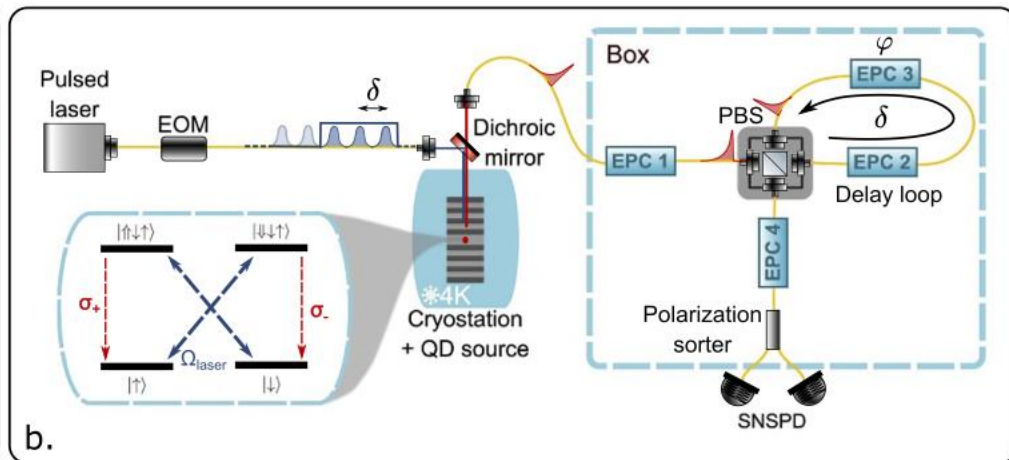
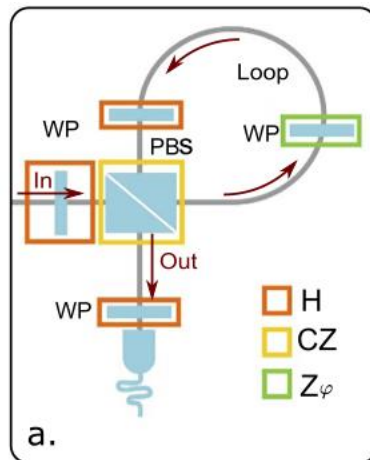
One way quantum computing



Building cluster states

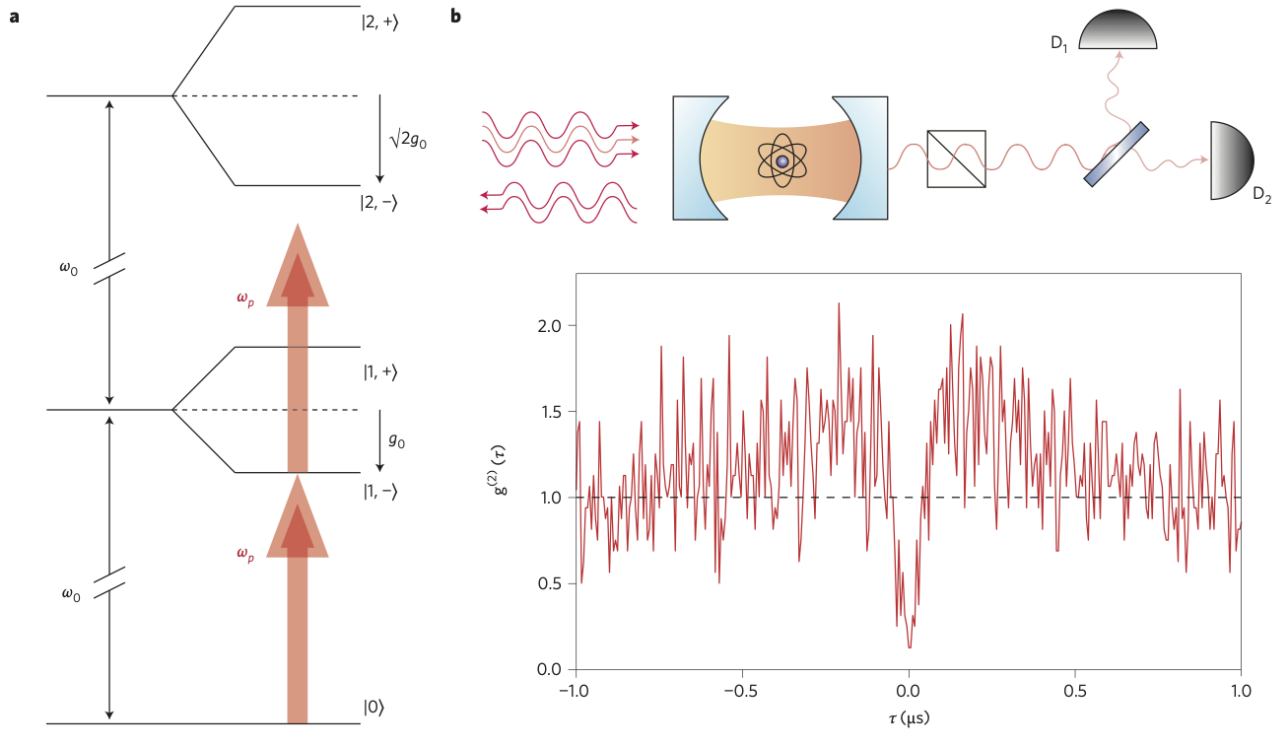


Senellart, Photonics 2021

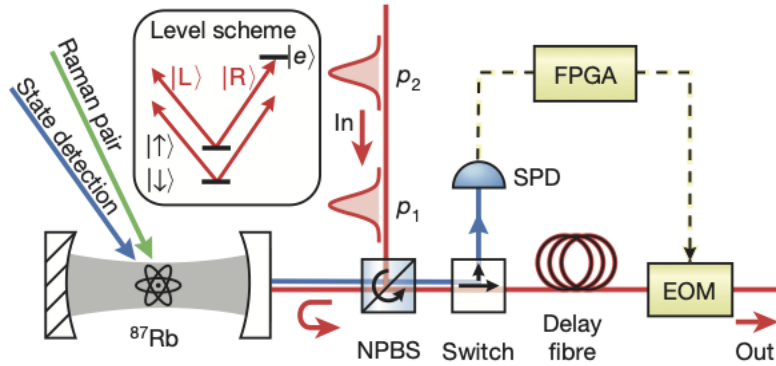


Guichard QST 2025

Photonic blockade



CQED based photon-photon gate



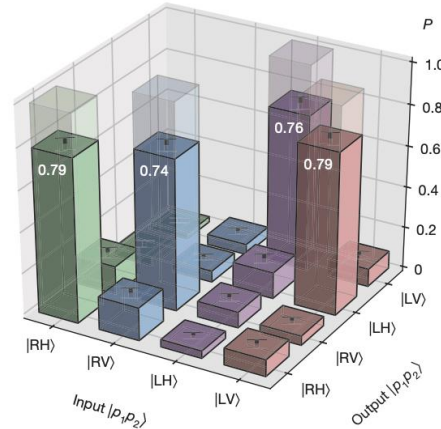
$$|RR\rangle \rightarrow |RR\rangle$$

$$|LR\rangle \rightarrow -|LR\rangle$$

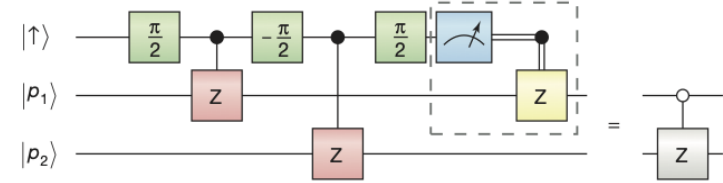
$$|RL\rangle \rightarrow |RL\rangle$$

$$|LL\rangle \rightarrow |LL\rangle$$

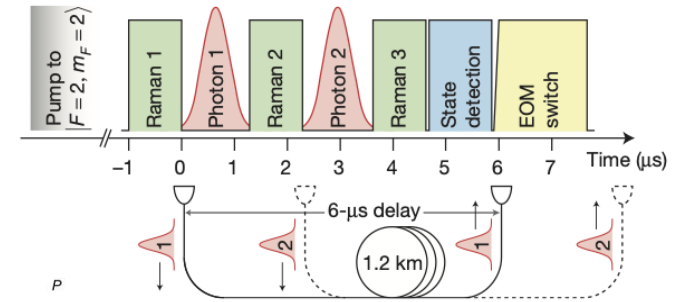
$$F = 76\%$$



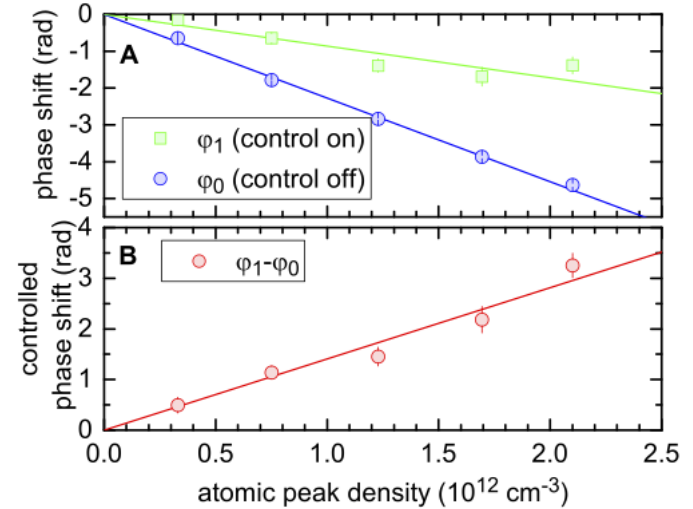
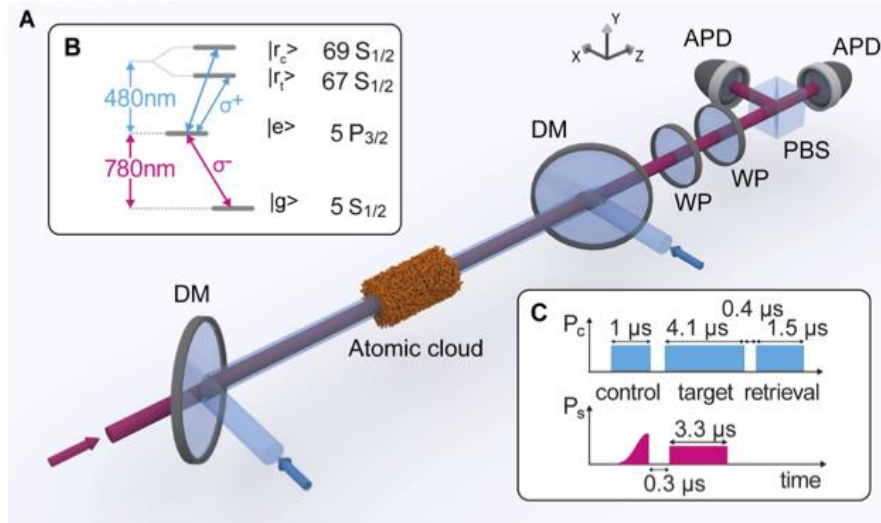
a Gate schematic



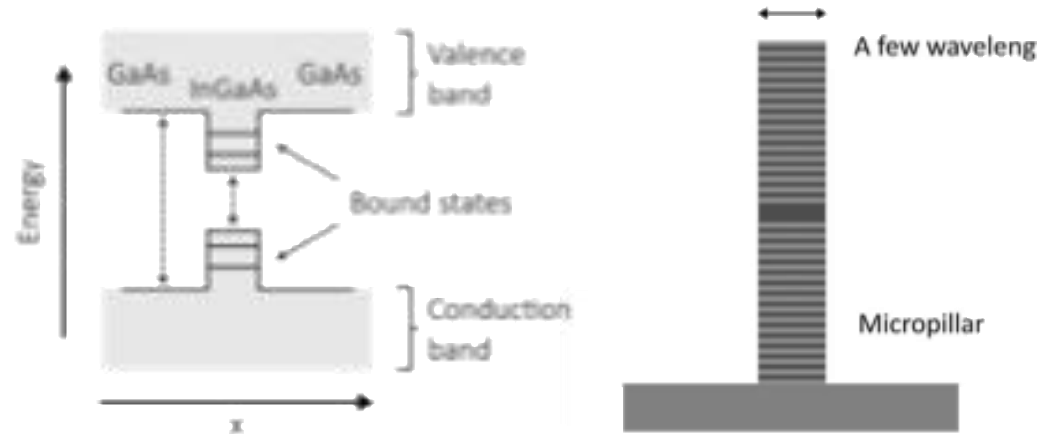
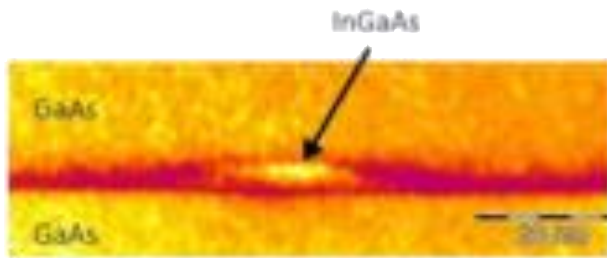
b Experiment



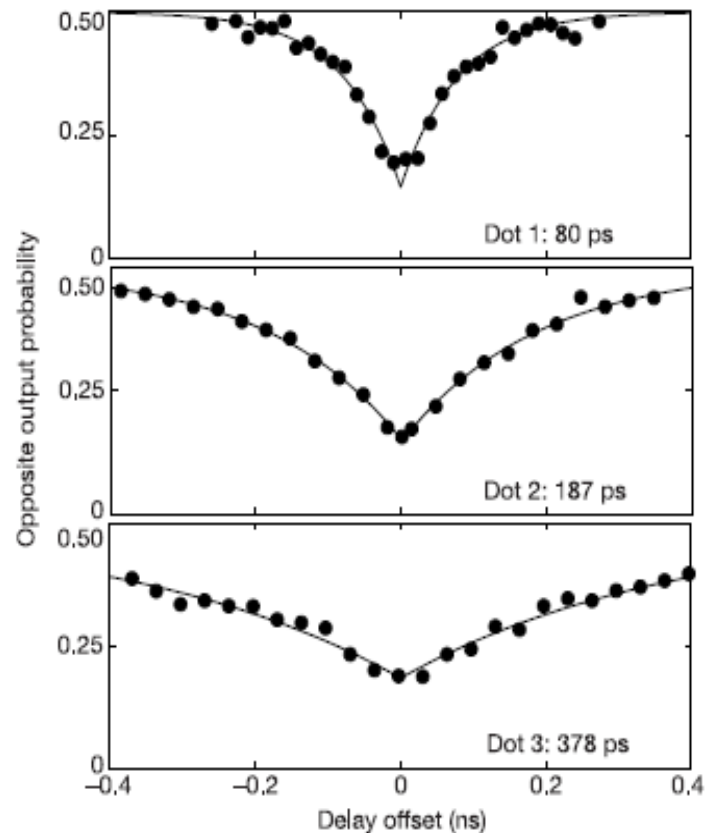
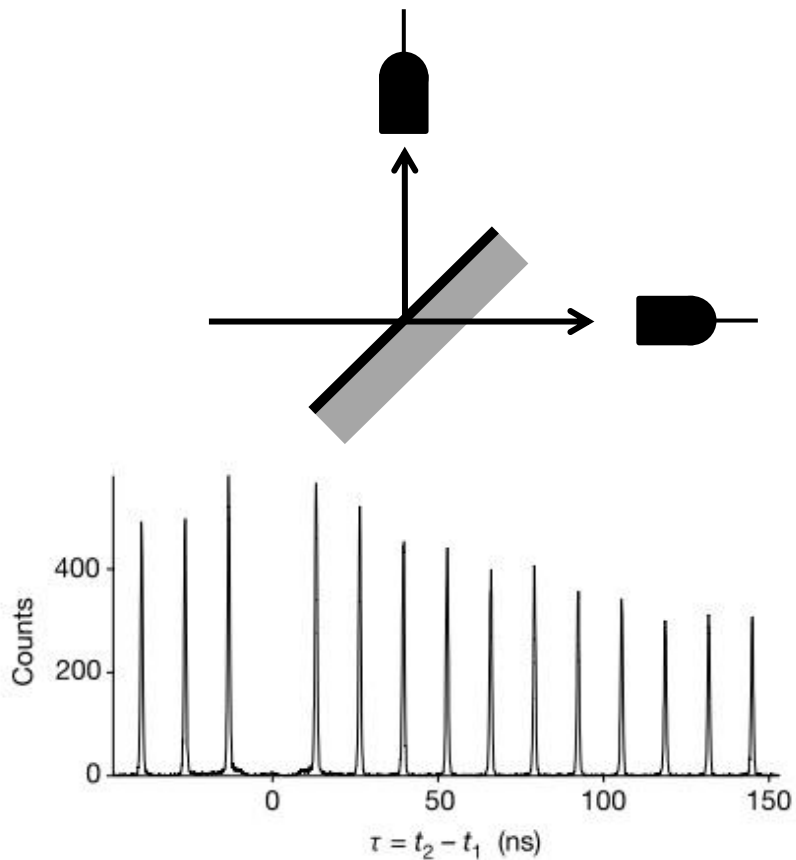
Rydberg induced non-linearity



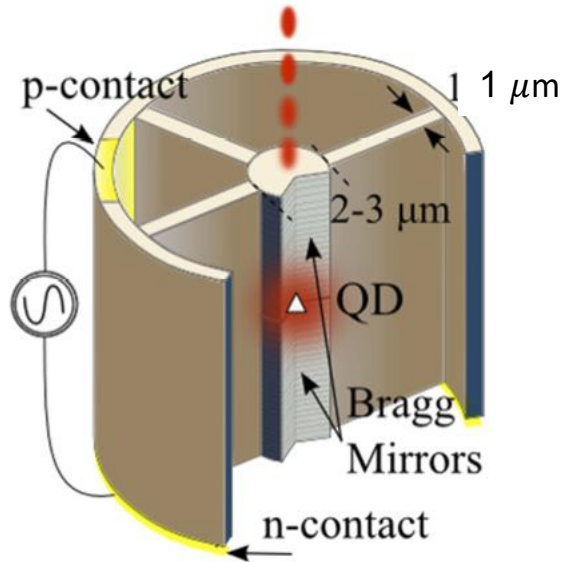
Single photon source based on quantum dots



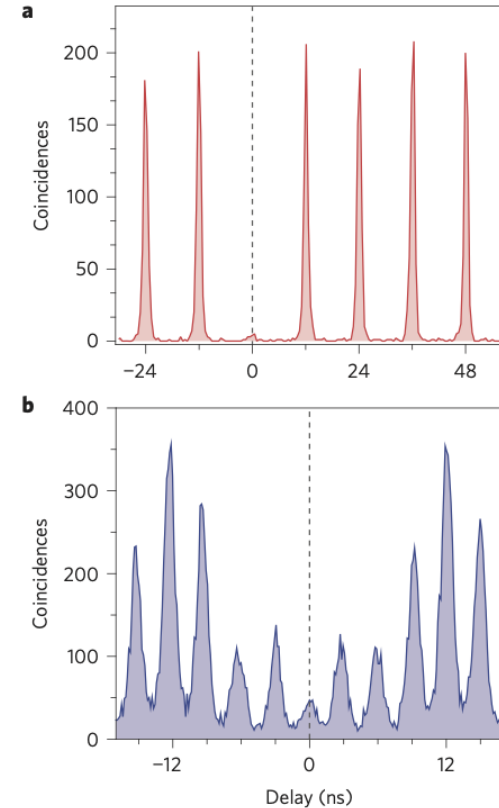
Single photon source based on quantum dots



Single photon source based on quantum dots

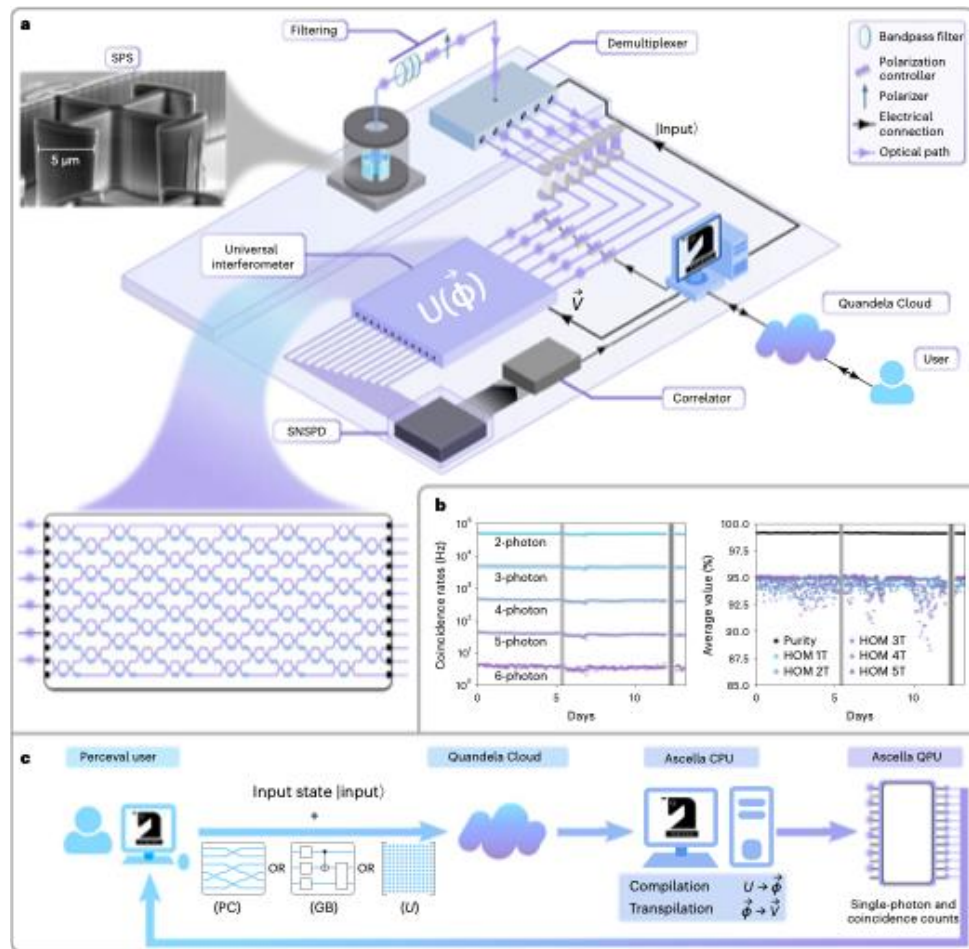


N. Somaschi, Nature 202016

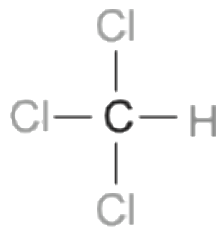




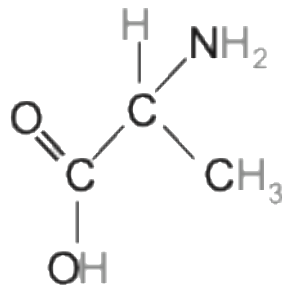
Nat. Phot. 2024



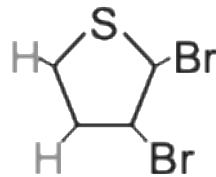
Molecules for NMR



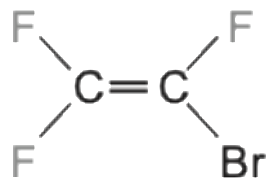
(a)



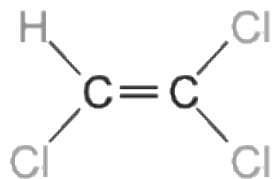
(b)



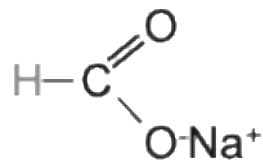
(c)



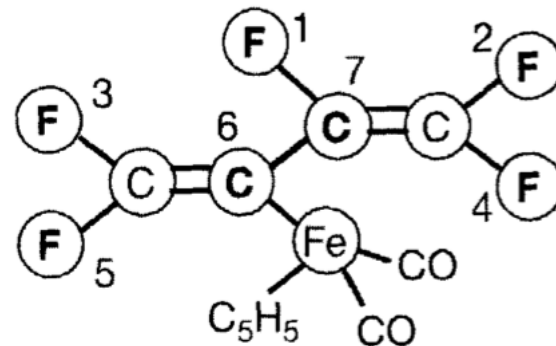
(d)



(e)



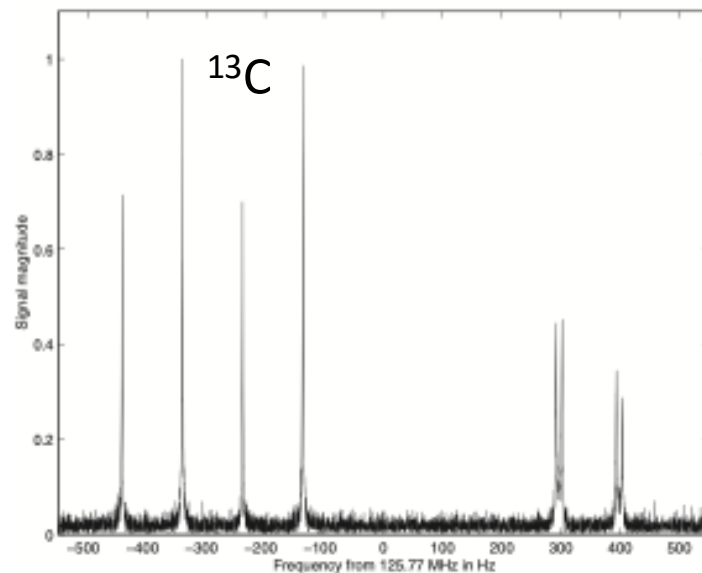
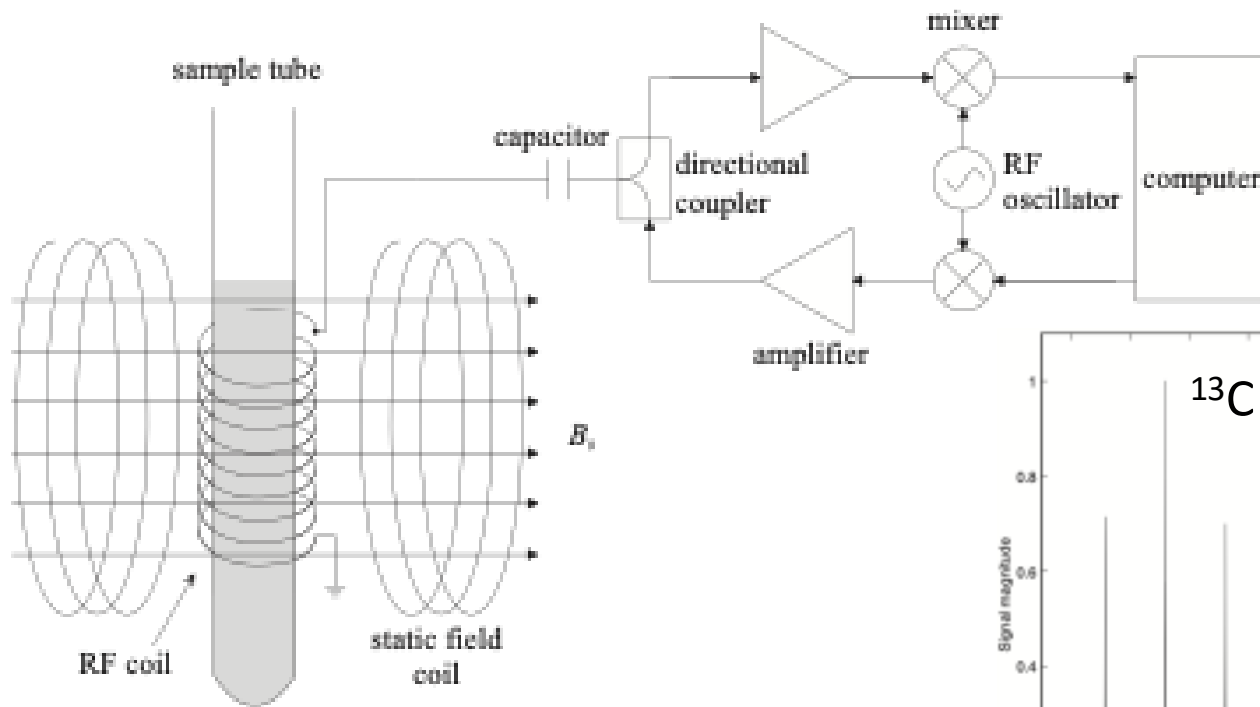
(f)



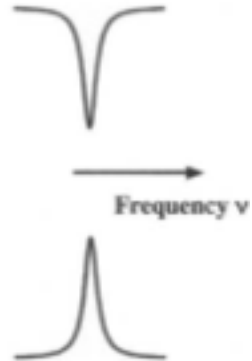
Vandersypen, Nature 1999

Nielsen & Chuang

Principle of Liquid NMR



Readout of two qubit state



ρ before pulse

A X
 $|00\rangle$
 $|01\rangle$
 $|10\rangle$
 $|11\rangle$

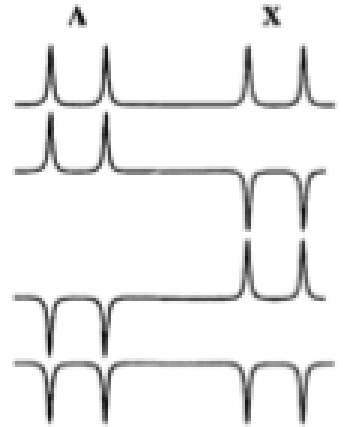
A Spectrum
 (selective pulse)



X Spectrum
 (selective pulse)

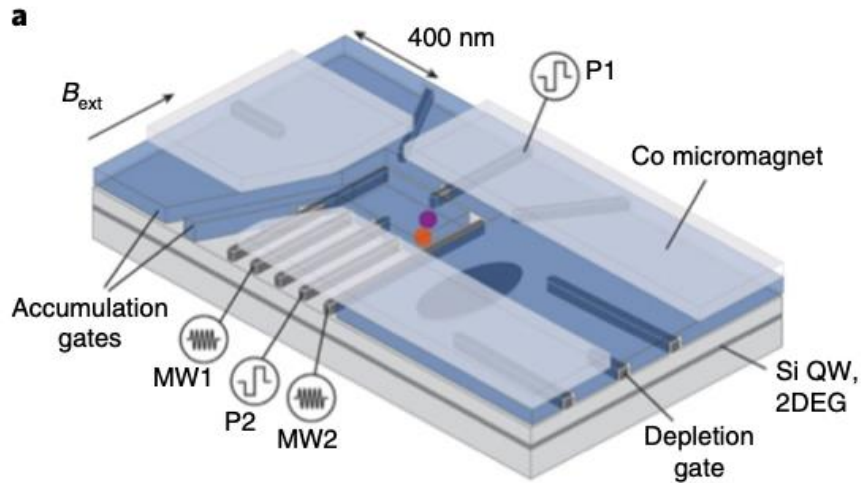


AX Spectrum
 (nonselective pulse)

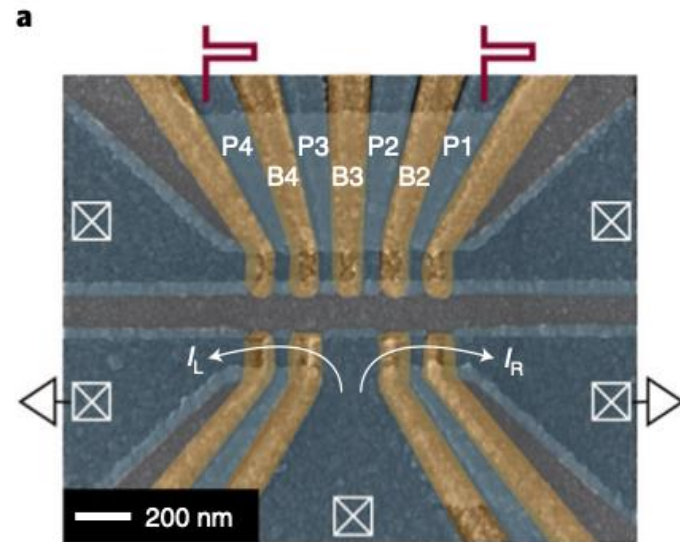


Stolze & Suter

Spin qubit on a Si hetero-structure



Vandersypen Nature 2018

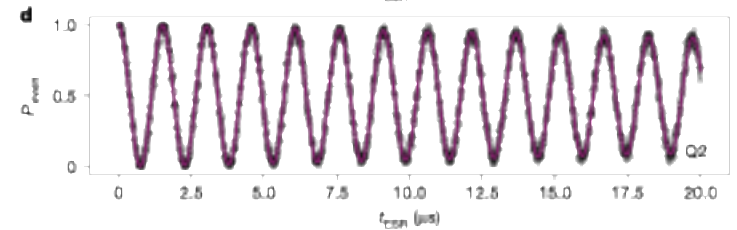
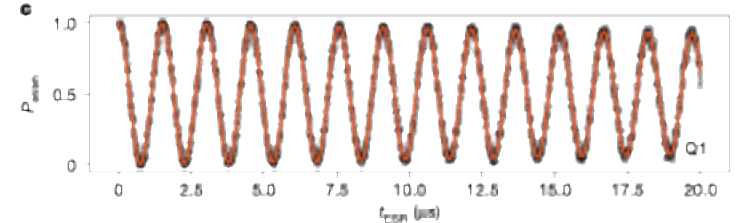
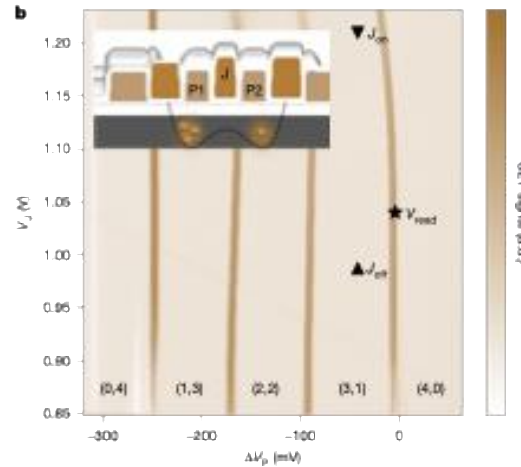
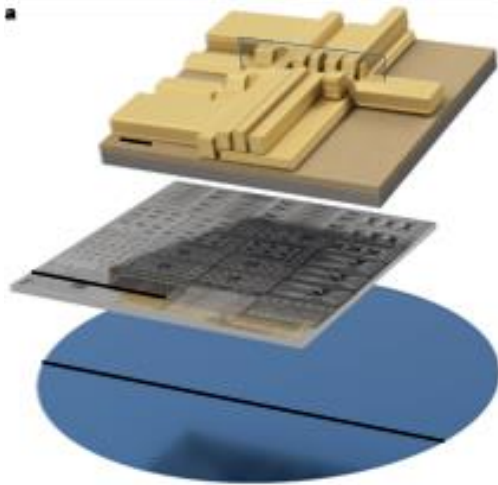


Heinrich *et al.*,
Nature Nanotechnology (2021)

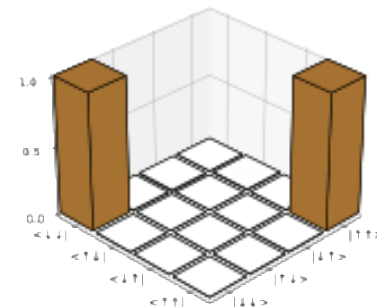
Article

Industry-compatible silicon spin-qubit unit cells exceeding 99% fidelity

Nature 2025



$F_{SPAM} = 99.95(8)\%$
even parity matrix



odd parity matrix

